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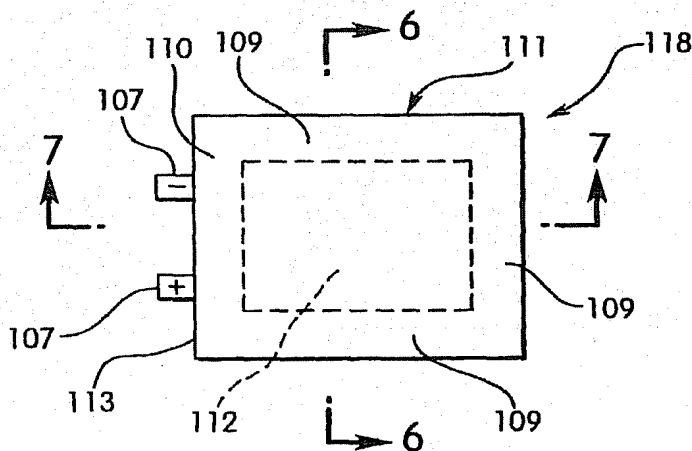
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(54) Title: BATTERY PACKAGING



(57) **Abstract:** A rechargeable battery, such as, a lithium ion battery, which includes a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each has a metal foil, an outer polymer layer bonded to one side of the metal foil, and a hot melt polymer coating on the other side of the metal foil in at least perimeter region of the metal aluminium foil. The metal foil is preferably aluminum foil. The hot melt polymer coatings in the perimeter regions of the first and second laminate are sealed together. A central chamber is formed by the central regions of the first and second laminate layers. There is an anode, a cathode and electrolyte arranged in an electrical current producing and conducting manner in the central chamber. Two electrically conductive strips positioned between the two perimeter regions. One end of the connect-

tors is connected to the anode, and one end of the other connector is connected to the cathode. Each other end of the two connectors extend beyond the perimeter regions of the laminates.

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BATTERY PACKAGING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to batteries, such as, lithium ion batteries, and to processes of preparing the batteries, such as, lithium ion and lithium polymer and lithium metal batteries. The invention also relates to battery packaging for batteries, such as, lithium ion batteries, and to processes of preparing such battery packaging for batteries, such as, lithium ion and lithium polymer and lithium metal batteries.

2. Discussion of The Problems

Currently, lithium ion batteries are packaged in a hard aluminum shell, which is impact formed or formed via deep-drawing. Such hard shells are laser-welded to keep the liquid electrolyte within the container, and to prevent the chemical content of the shell from being exposed to moisture, and other gases which impact the battery performance negatively. These casings are expensive to make, available from a very limited number of companies and also, more importantly, the shape and form factors available are very limited. For instance, the thickness of the case is not available in less than six (6) millimeters.

The exorbitant cost and the limitation in sizes, shape and thickness has driven the battery developers to a new approach to

protect and contain such lithium ion and lithium polymer batteries. The use of flexible aluminum-plastic laminates has been introduced. Their low cost, the intended forming ability of such laminates to provide deep cavities, the wide availability and their high protection to moisture and gases have made such materials understandably attractive as a concept. Also, the ease of varying the size, i.e., length, width and thickness, of such shapes provides the strongest argument for the choice of such materials for such applications. The current metal shell enclosure for batteries is also heavy and thick, when compared to the invention herein. Such properties, weight and thickness are key to new battery designs which need to be accommodated into ever smaller appliances, such as, cell-phone, lap-top computers, palm-top computers, notebook computers, cameras, etc. More and more, weight and size is what determines the end-customer preference for one or the other appliance. Furthermore, the battery performance itself is another determining factor for the sale of such products.

Over the last couple of years, the inventors herein and others have designed and provided early versions of new laminates for this application. These laminates were designed either for cold-forming purposes, such as, a formed rectangular, straight wall shaped cavity to house the battery bi-cells or as a pouch type, thinner structure for typical three-sided or fin-seal type pouches, the shape of which is well known to people skilled in

the art of packaging. All of these materials had a number of features in common:

They all contain an aluminum foil as the barrier material against gases, such as, moisture and oxygen, to light, and to prevent the liquid electrolyte from the battery to evaporate over time.

Beyond that, small variations were encountered from the type first made available commercially by Alusuisse Flexible Packaging in 1992. The latter is composed as:

<u>Formable</u>		<u>Non-formable</u>
oPA, 25µm	Outside	PET, 12µm
Adhesive		Adhesive
Aluminum foil,		Aluminum foil,
45 to 60 µm		10 to 60 µm
Tie layer		Tie layer
PET or oPA,	Inside	PET, 12 µm
12 to 25 µm		
Tie layer		Tie layer
Sealant, 50 µm		Sealant, 50 µm

Over time and in parallel with the development of the battery technology itself, the tie layers, thickness of sealant and foil were altered in some limited ways, and the sealant chemistry and tie layers were improved over time. Typically, the choice of sealant was made depending upon the chemistry of the battery and its electrolyte and the process used for manufacturing between acrylic acid modified polyethylene and polypropylene. The tie layers were, therefore, also chosen depending upon the above-mentioned sealant, and electrolyte, and type of packaging used between epoxy-urethane or aliphatic polyester type adhesives, and extended tie layers of acrylic acid

modified polyethylene and maleic anhydride modified polypropylene.

The thickness of the sealant and the presence of an intermediate film on the inside of the structure, such as, a PET (polyethylene terephthalate) or an oPA (oriented polyamide) film are designed for the relevant connector thickness. The connectors are metal strips made out of nickel, copper, aluminum or stainless steel. The connectors are sealed between the two sides of the package (such as, the top and the bottom for formed cavities, or the front and back for pouch-type packages). The connectors, also termed tabs, connect the anode and the cathode from the battery to the exterior, as the positive and negative poles, respectively.

The tab area constitutes the most complex part of the battery shell. As with the current aluminum hard shell, the aluminum-plastic laminate has to provide a very tight seal around the tabs to prevent the electrolyte from migrating out of the shell. At the same time, ingress of moisture along the same tabs must be prevented.

The intermediate plastic films, such as, the oPA film or the PET film, are imbedded to assure that when sealed, the sealant material is not squeezed in the tab area to the point where the tabs come in contact with the aluminum foil from the package. At which point, the battery would be shorted electrically. The oPA or PET films are not compressible at the temperatures used to

seal PP and PE, and, therefore, prevent the tabs from touching the foil. (PP is polypropylene and PE is polyethylene.) The sealant film or extrusion is designed in gauge to seal tabs in various thickness range, but, mostly, the tabs have a thickness between 50 and 80 microns, and, therefore, result in a tight, very thick seal. The sealant then also has to be very thick, which has some distinct disadvantages, as is shown below.

Therefore, materials of the state of the art are thick because of the inside heat and pressure resistant film, such as, the PET or oPA film, as well as the sealant material which is either polypropylene or polyethylene copolymer. The object of new battery designs is to minimize size and weight of such batteries. In order to maximize the volume for the battery bi-cells in the case of formed cavities, the formed walls are as straight as possible. The laminates used as the shell to protect the bi-cells, and contain the electrolyte, are expected to be as thin as possible. The materials of the current art are quite thick and, therefore, are bulky, heavy and take a lot of valuable space.

In order to reduce the size of the sealed and finished battery, the seals are typically folded down in the case of a formed bottom or folded along the body of the pouch. Such folded seals with the state of the art materials take a significant amount of space and volume, due to the thick nature of the packaging material. The volume left for the battery is very

significantly reduced because of the size of the folded seals.

The amount of electrolyte that is absorbed by the sealant material, either polypropylene or polyethylene, grafted or copolymerized, is significant and allows the electrolyte to evaporate over time. Typical electrolytes contain strong organic solvents, such as, alkyl carbonates, for example, ethyl carbonate, dimethylcarbonate, ethylmethyl carbonate, etc. These strong solvents are soluble in the layers of the state of the art laminates. Therefore, over time, the electrolyte found in solution in the sealant, the PET and oPA films and tie layers reduce the bond strength to some extent, but more importantly, such electrolyte will also evaporate slowly at the edge of the seal and the battery will dry out. Such batteries are exposed to temperatures as high as 120°C for short periods of time, temperatures such as 85°C for long term testing, and also cycling between 60°C and 95°C over a long period of time.

Typically, when tested at 60°C over extended periods of time, the electrolyte loss can be quite significant with the state of the art package. Also, some of the laminated materials of the current art lack forming capability and tend to crack at the corners of the formed cavity. The formed cavity requires almost straight wall angles (typically 4 degrees or less), which is a tremendous stress for the material. Most of the time, the lack of forming performance is associated with either the wrong choice of aluminum alloy or the wrong type of PET or polyamide

film. Once the aluminum foil is cracked by the forming process, the barrier protection of the battery, such as to prevent the electrolyte to evaporate, or moisture to ingress into the package, is compromised.

The major drawback with the state of the art packaging laminate, as described earlier, is that the tab area is extremely difficult to seal tightly with such laminates. Such poor seals lead to electrolyte leaking batteries and potential for corrosion of the battery and tabs due to moisture ingress. At any rate, the life and performance of the battery is compromised. Such difficulty comes from the need for the sealant material to be pressed during the heat seal process from its flat and homogenous finish along the edge of the tabs. During the heat seal process, the sealant must flow to "caulk" the edges of the tabs. By doing so, one takes the risk of pressing too much or too little of the sealant material alongside of the tabs. In either case, the seal will be weak and lead to leakage and migration which destroys the battery performance. The sealant material is not available in a variable quantity in the tab area as it is a web or extrusion as an integral part of the laminate. Therefore, various "thickness or sizes of tabs can only be accommodated by changing the sealant layer thickness. The drawback of this approach is that the sealant is then present in heavy gauge also everywhere else along the battery seals. In these areas, the sealant is not desired in such quantities, because it contributes to the moisture and

electrolyte migration. Along the seals of the battery which do not contain the tabs, the sealant should ideally be kept as thin as possible and as moisture and electrolyte tight as possible. The heat resistant films provided on the inside of the structure are intended to prevent the tabs during the heat seal process from touching the aluminum foil from the package. However, these films also contribute to the migration of electrolyte and of moisture, because neither of them are good barrier materials to either moisture or electrolyte. PET and oPA are not considered by a person skilled in the art to be high barrier materials to water vapor or electrolyte. This invention demonstrates that these materials can be eliminated while improving the barrier and tab seal performance.

It is also now clear that every tab size and thickness more or less would require a different laminated material to be adapted to a more or less perfect seal of the tabs. This is a very costly approach, as often as the volumes associated with certain battery or tab sizes are small, and, therefore, little or no economy of scale is possible.

BROAD DESCRIPTION OF THE INVENTION

An object of the invention is to provide batteries, such as, lithium ion batteries or lithium polymer batteries, and battery packaging which have improved sealing of the connectors and improved barrier performance to water vapor intrusion and

electrolyte migration. Another object of the invention is to provide batteries, such as, lithium ion batteries, and battery packaging which have thinner laminates, and side seals that are easier to fold, than the prior art batteries. Another object of the invention is to provide batteries, such as, lithium ion batteries, and battery packaging which have improved thermal resistance to high temperatures, and therefore a safer product. A further object of the invention is to provide batteries, such as, lithium ion batteries, and battery packaging which have the improved properties of the invention with connectors of various sizes. Another object of the invention is to provide batteries, such as, lithium ion batteries, and battery packaging which are smaller in size and less in weight than those of the prior art. A still further object of the invention is to provide laminates for batteries, such as, lithium ion batteries, and battery packaging which do not delaminate over time. Another object of the invention is to provide processes for preparing the invention batteries, such as, lithium ion batteries, and invention packages.

The objects of the invention are achieved by the invention batteries, such as, lithium ion batteries, invention battery packaging, and invention process of preparing them. Other advantages and objections of the invention are set forth herein or are obvious therefrom to a person skilled in the art.

The invention involves improved batteries, particularly improved lithium ion and lithium polymer batteries, and improved battery packaging for batteries, particularly lithium ion and lithium polymer batteries. The present thickness of lithium ion batteries is about 6½ mm or more. The new packaging allows for thinner materials, so the invention batteries can be as thin as a credit card.

More specifically, the invention involves a rechargeable battery which includes a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each comprise a metal foil, an outer polymer layer bonded to one side of the metal foil, and a hot melt polymer coating on the other side of the metal foil in at least perimeter region of the metal foil. The metal foil is preferably aluminum foil. The hot melt polymer coatings in the perimeter regions of the first and second laminate are sealed together. A central chamber is formed by the central regions of the first and second laminate layers. There is an anode, a cathode and an electrolyte arranged in an electrical current producing and conducting manner in the central chamber. Two electrically conductive connector strips are positioned between the two perimeter regions. The connectors are typically aluminum, copper or nickel. One end of one of the connectors is connected to the anode, and one end of the other connector is connected to the

cathode. Each other end of the two connectors extends beyond the perimeter regions of the laminates. The hot melt polymer forms very tight seals around the tabs which essentially prevent electrolyte leakage and moisture incursion.

The hot melt polymer has significantly different physical properties from the sealant polymer, even when the two are the same or similar chemicals (polymers), which contributes to the invention and its advantages. The hot-melt shows a low viscosity compared to the sealant material at its melting temperature.

More specifically, the invention also involves battery packaging which includes a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each comprises a metal foil, an outer polymer layer bonded to one side of the metal foil, and a hot melt polymer coating on the other side of the metal foil in at least perimeter region of the metal foil. The metal foil is preferably aluminum foil. The hot melt polymer coatings in the perimeter regions of the first and second laminate are sealed together. A central chamber is formed by the central regions of the first and second laminate layers. Two electrically conductive connector strips are positioned between the two perimeter regions. The connectors are typically aluminum, copper, or nickel. One end of one of the connectors is adapted for connection to the anode in the central chamber. One end of

the other connector is adapted for connection to the cathode. Each other end of the two connectors extends beyond the perimeter regions of the laminates. The hot melt polymer forms very tight seals around the tabs which essentially prevent electrolyte leakage and moisture incursion.

The purpose of the invention is not only to remedy the problems of thickness of the packaging laminate and the problem of tightly sealed tabs to prevent leakage and damage to the battery, but also to provide a more robust material for the forming process, and to reduce the electrolyte loss through the seals. In the case where no forming process is required or desired, a thinner and less expensive laminate can be used. In both cases, the hot melt concept is used to provide tight seals around the tabs. The materials of this invention also provide a significantly higher thermal resistance to the high temperature exposure that batteries can experience, and therefore creates a safer product.

The invention allows for a maximized flexibility in sealing various tab sizes and thickness by varying the amount and location of hot melt material. The remainder of the package still accommodates a seal with minimal sealant material to minimize moisture and electrolyte migration. The amount of hot melt must, however, be kept to a minimum in order to minimize thickness, size and cost but more importantly to minimize migration of electrolytes and water. The hot melt is designed

for maximized resistance to the electrolyte and also for a minimal absorption or solubility of the electrolyte. The hot melt is also chosen from materials with high moisture barrier performance, and low moisture solubility. The hot melt is made out of the same family of resin as the sealant material of the laminate in order to provide a strong weld with the package, when the tabs and the hot melt are sealed together.

The hot melt can be applied at various locations and sequences of the battery assembly. It can also be applied on the tabs of the battery themselves prior or after the introduction of the battery in the package. The hot melt can also be applied directly onto the packaging material, for instance after forming, if the package is a formed cavity, or after folding, if the package is a pouch type.

The hot melt application itself is carried out with a gear pump unit from a heated tank containing the hot-melt, and dispensed through nozzles at the desired location. The hot-melt application principle is well known to people skilled in the art of packaging.

The hot melt material is designed, as mentioned above, from the same family of organic polymers as that from which the sealant in laminate is composed, so that the melting points of both materials are close together. This allows, among other things, the hot melt to be applied either on the packaging material or on the battery tabs and cooled down to the solid

state. When reaching the final assembly of the battery in the package and such package is heat sealed, the side seals without tabs are sealed under conventional heat, pressure and time. The part of the package with the tabs protruding through the seal (periphery regions) of the package, where the hot melt has been applied is also sealed by the same process of heat, pressure and time. The hot melt is reactivated by the heat and pressure and bonds with the packaging material and the tabs and, when made molten by the heat and pressure, caulks the sides of the tabs so that the seal is perfectly tight. The similar nature of the package sealant and the hot melt allows for heat sealing with the same parameters of heat, pressure and time as for the side seals. When the sealing jaws are opened, the material is allowed to cool down, and both the sealant material and hot melt solidify into very strong seals. These seals are mechanically strong so as to resist the mechanical and thermal stresses of the life cycle of the battery.

As used herein, the term electrolyte (or electrolytic conductor) means a conducting medium in which the flow of current is accompanied by the movement of matter in the form of ions. The conducting medium is a liquid or a paste.

Lithium ion batteries use a liquid (nonaqueous) electrolyte. The negative electrode is usually graphite or other carbon material which is able to intercalate lithium ions. The positive electrodes are lithium compounds or alloys, such as, LiCoO_2 .

Lithium polymer batteries use a paste electrolyte which is usually a mixture of oxides including at least one oxide.

The invention deals with primary batteries and particularly with secondary batteries such as lithium polymer batteries and preferably lithium ion batteries. The lithium ion and polymer batteries are rechargeable.

The invention involves a lithium battery including a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each comprises a metal foil, an outer polymer layer bonded to one side of the metal foil, and an inner polymeric sealant layer on the other side of the metal foil. The inner polymeric sealant layers of the perimeter regions of the first and second laminates are sealed together. A central chamber is formed by the central regions of the first and second laminate layers. There is an anode, a cathode which is a lithium compound or alloy, and electrolyte arranged in an electrical current producing and conducting manner in the central chamber. Two electrically conductive connector strips are positioned between the two perimeter regions. One end of one of the connectors is connected to the anode, and one end of the other connector is connected to the cathode. Each other end of the two connectors extends beyond the perimeter regions. A hot melt polymer is located in a sealing manner between each of the connectors and the perimeter

regions of the sealant layers in the area of and around each of the connectors. The hot melt polymer forms very tight seals around the tabs which essentially prevent electrolyte leakage and moisture incursion.

The metal foil is, for example, aluminum foil, soft annealed aluminum alloy foil (preferred), copper foil, soft annealed copper alloy foil or nickel. The lithium battery can be a lithium polymer battery, with the metal foil as an aluminum foil. The lithium battery can be a lithium ion battery. The metal foil can be an aluminum foil having a thickness of 5 to 100 μm . The aluminum foil can be soft annealed aluminum foil.

The inner polymeric sealant layer can be a maleic anhydride grafted polypropylene, an epoxy-propylene material or system, propylene, an acrylic acid modified propylene, polyethylene, a polyamide, a polyester or a urethane. The inner polymeric sealant layer can have a thickness of 5 to 100 μm . The inner polymeric sealant layer can have a melting point of at least 90°C, preferably of at least 120°C.

The hot melt polymer can be a maleic anhydride grafted propylene, an epoxy-propylene or system, propylene, an acrylic acid modified propylene, polyethylene, a polyamide, a polyester or a urethane, which has been hot melt applied. The hot melt polymer can have a melting point of at least 90°C, preferably of at least 120°C, and which is similar to the melting point of the inner polymeric sealant layer. The hot melt polymer can be a

coating over the entire surface of each of the inner polymeric sealant layers.

The outer polymeric layer can be a polyester or a polyamide or polypropylene. The outer polymeric layer can have a thickness of 8 to 50 μm . The outer polymeric layer can be a biaxially oriented polyamide, a biaxially oriented polyester or biaxially oriented polypropylene. The outer polymeric layer can be bonded to the metal foil by means of an adhesive layer or a tie layer. The adhesive layer can be a solvent based or solvent free urethane based adhesive or polyester based adhesive or epoxy-based one or two component adhesive. The tie layer can be polyethylene, or acrylic acid modified polyethylene or polypropylene.

The lithium battery can have a pouch shape, or have a rectangular (prismatic) straight wall shaped cavity, or be of the three-sided or fin-seal type pouch.

The invention involves a lithium battery packaging including a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each comprises an aluminum foil, an outer polymer layer bonded to one side of the aluminum foil, and an inner polymeric sealant layer on the other side of the aluminum foil. The inner polymeric sealant layers of the perimeter regions of the first and second laminates are sealed together. A central chamber is formed by

the central regions of the first and second laminate layers. Two electrically conductive connector strips are positioned between the two perimeter regions. One end of one of the connectors is adapted for connection to an anode in the central chamber, and one end of the other connector is adapted for connection to a cathode in the central chamber. Each other end of the two connectors extends beyond the perimeter regions. A hot melt polymer is located in a sealing manner between each of the connectors and the perimeter regions of the sealant layers in the area of and around each of the connectors. The hot melt polymer forms very tight seals around the tabs which essentially prevent electrolyte leakage and moisture incursion.

The invention involves a lithium ion battery including a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each comprises an aluminum foil, an outer polymer layer bonded to one side of the aluminum foil, and a hot melt polymer coating on the other side of the aluminum foil in at least perimeter region of the aluminum foil. The hot melt polymer coating in the perimeter regions of the first and second laminates are sealed together. A central chamber is formed by the central regions of the first and second laminate layers. There is an anode, a cathode which is a lithium compound or alloy, and electrolyte arranged in an electrical current producing and conducting manner in the central

chamber. Two electrically conductive connector strips are positioned between the two perimeter regions. One end of one of the connectors is connected to the anode, and one end of the other connector is connected to the cathode. Each other end of the two connectors extends beyond the perimeter regions of the laminates. The hot melt polymer forms very tight seals around the tabs which essentially prevent electrolyte leakage and moisture incursion.

The lithium battery is, for example, a lithium polymer battery or a lithium ion battery. The metal foil can be aluminum foil having a thickness of 5 to 100 μm . The aluminum foil can be soft annealed aluminum foil.

The inner polymeric sealant layer is a maleic anhydride grafted polypropylene, an epoxy-propylene material or system, propylene, an acrylic acid modified propylene, polyethylene, a polyamide, a polyester or a urethane. The inner polymeric sealant layer can have a thickness of 5 to 100 μm and can have a melting point of at least 90°C, preferably of at least 120°C.

The hot melt polymer can be a maleic anhydride grafted propylene, an epoxy-propylene or system, propylene, an acrylic acid modified propylene, polyethylene, a polyamide, a polyester or a urethane which has been hot melt applied. The hot melt polymer can have a melting point of at least 90°C, preferably of at least 120°, and which is similar to the melting point of the inner polymeric sealant layer.

The outer polymeric layer can be a polyester or a polyamide. The outer polymeric layer can have a thickness of 8 to 50 μm . The outer polymeric layer can be bonded to the metal foil by means of an adhesive layer or a tie layer. The adhesive layer can be a solvent based or solvent free urethane based adhesive or polyester based adhesive or epoxy-based one or two component adhesive. The tie layer can be polyethylene, or acrylic acid modified polyethylene.

The lithium battery can have a pouch shape, or have a rectangular straight wall shaped cavity, or be of the three-sided or fin-seal type pouch.

The invention further involves a lithium battery packaging which includes a first laminate layer having a perimeter region and a central region, and a second laminate layer having a perimeter region and a central region. The first and second laminate layers each comprises an aluminum foil, an outer polymer layer bonded to one side of the aluminum foil, and a hot melt polymer coating on the other side of the aluminum foil in at least perimeter region of the aluminum foil. The hot melt polymer coatings in the perimeter regions of the first and second laminates are sealed together. A central chamber is formed by the central regions of the first and second laminate layers. Two electrically conductive connector strips are positioned between the two perimeter regions. One end of one of the connectors is adapted for connection to an anode in the central chamber, and

one end of the other connector is adapted for connection to a cathode in the central chamber. Each other end of the two connectors extends beyond the perimeter regions of the laminates. The hot melt polymer forms very tight seals around the tabs which essentially prevent electrolyte leakage and moisture incursion.

If the inner surfaces of the metal foils of the laminates are not completely covered by sealant coating or hot melt polymer coating, the metal foil in the laminates in the seal area should be nonconductive or the edges sealed of the laminates should be covered with a non-electrically conductive polymer or other material so as not to cause electrical shorting of the batteries.

The lithium ion and lithium polymer batteries of the invention are very small (thin and ultra thin) and can be used in cell-phones, lap-top computers, cameras, palm top computers, notebook computers, electric shavers, cordless phones, pagers, beepers, calling cards, garage door openers, baby monitors, wireless microphones, portable electronic products and the like. The batteries of the invention include other batteries which use alternative chemical systems. The batteries of the invention can include solid state lithium batters (i.e., no liquid or paste electrolyte).

The outer polymer layer of the invention laminates is generally a polyamide, polyester or polypropylene film/layer.

The outer polymer layers of the laminates can be, for example, a polyamide-based thermoplastic comprised mainly of

polyamide-based thermoplastics. Belonging to the polyamide-based thermoplastics are, for example, the polyamides polyamide 6, a homopolymer of ϵ -caprolactam (polycaprolactam); polyamide 11, polyamide 12, a homopolymer of ω -laurinlactam (polylaurinlactam); polyamide 6.6, a homo-poly-condensate of hexamethylene-adiamine and adipinic acid (poly-hexamethylene-adipamide); polyamide 6.10, a homo-poly-condensate of hexamethylene-diamine and sebacinic acid (poly-hexamethylene-sebacamide); polyamide 6.12, a homo-poly-condensate of hexamethylene-diamine and dodecandic acid (poly-hexamethylene-dodecanamide) or polyamide 6-3-T, a homo-poly-condensate of trimethyl-hexamethylene-diamine and terephthalic acid (poly-trimethyl-hexamethylene-terephthalamide), and mixtures therefrom. Preferred are polycaprolactams.

The outer polyamide layers can include, e.g., monofilms or monolayers and composites of two or more films or layers of polyamides, polyamide mixtures or mixed, block, grafted or copolyamides.

The outer polyamide layers can be present as monofilms, however, also as composites of two or more films.

The outer polyamide layers or films contain additives, such as, stabilizers, softeners, filler materials, pigments, etc.

The outer polyamide layers can be stretched and are usefully uniaxially, preferably biaxially stretched. The outer polyamide

layers can contain or be stretched polyamide-based thermoplastics. Very strongly preferred are uniaxially or in particular biaxially stretched polyamide films.

The flow behavior of the outer polyamide layer in the form of films and in particular in the form of biaxially stretched polyamide films is usefully as isotropic as possible.

Furthermore, the outer polyamide films that are preferred are those with a flow behavior that results in a high degree of strain hardening. The high degree of strain hardening is evidence of increasing stress in the film in the longitudinal and transverse directions with increasing elongation.

Particularly suitable polyester, polyamide or polypropylene layers have a high R value, an R value lying in particular above 1. The R value expresses whether the material yields preferably from the width or from the thickness of the particular film. An R value above 1 denotes that the material yields preferably from the width of the sample.

The preferred films include, for example, biaxially oriented polypropylene and particularly preferred polyamide or polyester films having a tensile strength in both directions of more than 150 MPa, preferably more than 200 MPa.

The extension to break of preferred films is, for example, above 40 percent and in particular above 50 percent. The tension in the extension region of 5 to 15 percent in preferred films is advantageously between 40 and 120 MPa and in particular between

50 and 100 MPa.

The metal foil or layer of the formable laminate of the invention can be, for example, iron, steel or copper. A preferred metal foil is aluminum or an aluminum alloy. A metal layer is advantageously aluminum having a purity of 98.6 percent and higher, preferably 99.2 percent and higher, and particularly preferably 99.5 percent and higher. Aluminum alloys, for example, of the type AA8079 or AA8101 or AA8021, are also advantageous.

A soft-annealed, fine-grain and/or largely texture-free (isotropic) aluminum thin tape, i.e., a continuous metal layer that has no perforations, cuts or discontinuities, in particular having at least 5 and particularly preferably 7 grain layers over the thickness of the tape, is particularly preferred as a metal layer.

The surface of the metal layer and in particular the aluminum layer is preferably homogeneous, without residual greases and having a defined surface. The aluminum surfaces can be treated, for example, with stoving lacquers based on epoxide or phenol, or with conversion layers, such as mixed oxide and/or hydrate layers. Furthermore, the surfaces can be pretreated by means of a corona discharge treatment.

The laminating adhesive is advantageously used to join the outer polymer film/layer to the aluminum foil. The laminating adhesive can be applied to the surface to be adhered by lacquer

laminating.

Examples of suitable adhesives are vinyl chloride copolymers, vinyl chloride-vinyl acetate copolymers, polymerizable polyesters, vinylpyridine polymers, vinylpyridine polymers in combination with epoxy resins, butadiene-acrylonitrile-methacrylic acid copolymers, phenol resins, rubber derivatives, acrylic resins, acrylic resins with phenol or epoxy resins or acrylate copolymers, or organosilicon compound, such as organosilanes.

The organosilanes are preferred. Examples of these are alkyltrialkoxysilanes having an amino functional group, alkyltrialkoxysilanes having an epoxy functional group, alkyltrialkoxysilanes having an ester functional group, alkyltrialkoxysilanes having an aliphatic functional group, alkyltrialkoxysilanes having a glycidoxy functional group, alkyltrialkoxysilanes having a methacryloxy functional group, and mixtures thereof. Examples of those organosilanes are Y-aminopropyltriethoxysilane and N- β -(aminoethyl)-Y-aminopropyltrimethoxysilane, Y-(3,4-epoxycyclohexyl)-ethyltrimethoxysilane, Y-glycidoxypropyltrimethoxysilane, and Y-methacryloxypropyltrimethoxysilane. These compounds are known per se in the specialist field.

Further suitable adhesion promoters are adhesives, such as for example nitrile rubber-phenol resins, epoxides, acrylonitrile-butadiene rubber, urethane-modified acrylics,

polyester co-polyamides, hot-melt polyesters, polyisocyanates cross-linked with hot-melt polyesters, polyisobutylene-modified styrene-butadiene rubbers, polyurethanes, ethylene-acrylic acid mixed polymers and ethylene-vinyl acetate mixed polymers.

The polyurethanes are particularly preferred. Depending on the type, the adhesives may be used with or without solvents or from aqueous solution.

As a rule the adhesive layer thickness is kept from 1 to 12 μm and preferably 1.5 to 9 μm . Instead of the layer thickness, the amount of adhesive, especially between the metal foil and the outer polymer film arranged right next to the side of the metal layer, can be expressed by the amount of laminating adhesive. The amount is, for example 1.0 to 14 g/m^2 , advantageously 1.5 to 9 g/m^2 , and preferably 1.5 to 6 g/m^2 . The amount is given without miscellaneous solvent. The outer polymer films may be heat-laminated on the aluminum surface.

The polypropylene sealant is a base polyolefin material, such as, atactic or isotactic polypropylene. In order to promote adhesion to metal, grafting of functional groups to the base polyolefin material is performed. Maleic anhydride grafting of polypropylene is a typical type modification to promote metal adhesion.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a top view of the formed version of a prior art lithium ion battery;

Figure 2 is a lateral cross-sectional view along line 2-2 in Figure 1;

Figure 3 is a longitudinal cross-sectional view along line 3-3 in Figure 1;

Figure 4 is a cross-sectional view of the formed version of the tab region of the prior art battery of Figure 1;

Figure 5 is a top view of the invention lithium ion battery;

Figure 6 is a lateral cross-sectional view along line 6-6 in Figure 5;

Figure 7 is a longitudinal cross-sectional view along line 7-7 in Figure 5;

Figure 8 is a longitudinal cross-sectional view of the tab region of the invention battery of Figure 5;

Figure 9 is another longitudinal cross-sectional view of the tab region of the prior art battery for comparison with Figure 10;

Figure 10 is another longitudinal cross-sectional view of the tab region of the invention battery for comparison with Figure 9;

Figure 11 is a perspective view of the fin-seal type of the pouch version of the invention lithium ion battery;

Figure 12 is a lateral cross-sectional view along line 12-12 of the central chamber region in Figure 11;

Figure 13 is a partial perspective view of the non-tab end of the invention battery of Figure 11;

Figure 14 is an end view of the invention battery of Figure 11;

Figure 15 is a partial perspective view of the tab end of the invention battery of Figure 11;

Figure 16 is a lateral cross-sectional view along line 16-16 of the tab region of the invention battery of Figure 11;

Figure 17 is a top view of the pouch version of the invention lithium ion battery;

Figure 18 is a side view of the invention battery of Figure 17; and

Figure 19 is a front view of the invention battery of Figure 17.

DETAILED DESCRIPTION OF THE INVENTION

The materials described here, in combination with the use of the hot melt to seal the tabs, provide an improved and novel package for lithium-based batteries. The invention provides a lighter package which prevents leakage of the electrolyte and impermeability to moisture particularly, and to some extent oxygen (true for the laminate and the hot melt). The critical sealing of the tabs and the making of a tight seal at that location is what the invention helps to improve with a novel

approach.

Tabs of various thickness and sizes can easily be accommodated, without changing any of the materials, by simply controlling the amount and placement of the hot melt.

Other benefits of the invention are thinner materials, which also are lighter and, therefore, minimize the weight and size of the battery. These materials also provide seals that are easier than the state of the art materials to bend into small radii in order to also minimize the overall battery size.

Sealant materials and hot melt materials can be, for example,

- Maleic anhydride grafted polypropylene (a preferred polymer)
- Epoxy-polypropylene systems
- Polypropylene
- Acrylic acid modified polyethylene (also known as EAA)
- Polyethylene
- Polyamide
- Polyester

The thickness of the sealant can be from 5 to 100 μm , preferably from 5 to 50 μm , and most preferred from 5 to 20 μm .

The choice of sealant concentrates on materials which have a melt point (seal resistance) higher than the temperature to which batteries are exposed, such as 120°C (for safety purposes), and have resistance to the electrolyte, at high temperatures.

The choice of hot melt polymer is also tied to a similar chemistry and melt point as the sealant in order for the laminate to allow for ease of sealing and caulking of the sides of the tabs.

The sealant material and the hot melt are also chosen to minimize electrolyte loss and moisture migration, both of which are detrimental to battery performance. Therefore, thin sealants and minimal amounts of hot melt are recommended to limit migration.

Another important factor is that, when compared to the state of the art (prior art) laminates, the invention provides a package that can by no means delaminate over time between the layers. The state of the art materials are sensitive to chemical degradation over time, as well as creep, which tends to delaminate part of the structure over time, and expose the battery to migrations. The invention does not delaminate and expose the battery to migration. In practice, this is a tremendous advantage of the invention.

The hot melt can also be used advantageously with fin-seal type pouches, certainly on the tab side, and also on the opposite side, where the fin joins the end-seal, by caulking the material overlap, which is typically a weak seal or one that is difficult to perform on a pouching machine.

As far as the metal layer is concerned, there is a difference depending upon whether or not the material has to be

formable:

Formable

- aluminum alloy 98.6 percent pure or higher, soft annealed
- gauge from 10 to 100 μm , preferably 20 to 70 μm and most preferably 25 to 60 μm , (one reduction to practice was 45 μm , but could readily also be 60 μm)
- the metal could also be copper or copper alloys, soft annealed, or nickel, for example.

Non-formable

- aluminum 98.6 percent or higher, soft annealed
- gauge from 5 to 100 μm , preferably 10 to 50 μm , and most preferably 10 to 30 μm , (one reduction to practice was 25 μm)
- the metal could also be copper or copper alloys, soft annealed, or nickel, for example.

For the outside layers:

For formable structures, the preferred material is biaxially oriented polyamide 6 or 6.6, with a gauge from 10 to 100 μm , preferably 10 to 50 μm , and most preferably 10 to 30 μm (one reduction to practice was 25 μm biaxially oriented polyamide).

The use of other materials, such as, biaxially oriented polyester and biaxially oriented polypropylene, in the same thickness ranges can also be used.

The outside layers can be bonded to the metal via an adhesive layer, which can be urethane based, or polyester based, or epoxy-

based one or two component adhesives, solvent based or solvent free. The outside layers could also be bonded to the metal with an extruded tie layer made of polyethylene or modified polyethylene, such as, acrylic-acid modified polyethylene. For non-formable structures, the preferred material is a biaxially oriented polyester film, or biaxially oriented polyamide, or biaxially oriented polypropylene. The gauge (thickness) can be from 10 to 100 μm , preferably 10 to 50 μm , and most preferably 10 to 30 μm , (one reduction to practice was 12 μm biaxially oriented polyester).

The laminates in the non-formable embodiment are very flexible, more so than the formable embodiment.

Figures 1 to 4 show embodiments of prior art (state of the art) lithium ion battery 100. Figure 1 shows a top view of lithium ion battery 100 with two metal tabs 107 extending beyond perimeter region 111, which surrounds central chamber 112. Perimeter region 111 includes front seal area 113 and side and back seal areas 109. Figure 2 is a lateral cross-sectional view of lithium ion battery 100. Stacked bi-cells 108 are shown in central chamber 112. The electrolyte is contained in central chamber 112. Side seal areas 109 are shown with bent over portions 114, which in the actual battery assembly are completely folded under. Figure 3 is a longitudinal cross-sectional view of lithium ion battery 100. Aluminum tabs 107 extend completely through front seal area 113 and connect with stacked bi-cells 108

by means of aluminum flat leads 115. Central chamber 112 is formed in bottom laminate 116 and is covered by top laminate 117. Front seal area 113 and side and back seal areas 109. Referring to Figure 4, top laminate 117, from the outside layer to the inside layer, is composed of:

- 101 - Polyethylene terephthalate (PET) or oriented polyamide (OPA) film
- 102 - Urethane adhesive layer
- 103 - Aluminum foil
- 104 - Urethane or acrylic acid modified polyethylene (EAA) layer
- 105 - Polyethylene terephthalate film
- 106 - Polypropylene (PP) or acrylic acid modified polyethylene sealant layer.

Referring to Figure 4, bottom laminate 116, from the inside layer to the outside layer, is composed of:

- 106 - Polypropylene or acrylic acid modified polyethylene sealant layer
- 105 - Polyethylene sealant terephthalate film
- 104 - Urethane or acrylic acid modified polyethylene layer
- 103 - Aluminum foil
- 102 - Urethane adhesive layer
- 101 - Polyethylene terephthalate or oriented polyamide layer.

As seen in Figure 4, aluminum tab(s) 107 lies between and is bonded (tab seal 110) to inner sealant layers 106 of top laminate 117 and bottom laminate 116. The seals around tabs 107 are prone to electrolyte leakage and moisture incursion.

Figure 5 to 8 show preferred embodiments of invention lithium ion battery 118. Figure 5 show a top view of lithium ion battery 118 with two metal tabs 107 extending beyond perimeter region 111, which surrounds central chamber 112. Perimeter

region 111 includes front seal area 113 and side and back seal areas 109. Figure 6 is a lateral cross-sectional view of lithium ion battery 118. Stacked bi-cells 108 are shown in central chamber 112 (which has a rectangular horizontal cross-section). The electrolyte is contained in central chamber 112. Side seal areas 109 are shown with bent over portions 114, which in the actual battery assembly are completely folded under. Figure 7 is a longitudinal cross-sectional view of lithium ion battery 118. Aluminum tabs 107 extend completely through front seal area 113 and connect with stacked bi-cells 108 by means of aluminum flat leads 115. Central chamber 112 is formed in bottom laminate 119 and is covered by top laminate 120. Front seal area 113 and side and back seal areas 109. Referring to Figure 8, top laminate 120, from the outside layer to the inside layer, is composed of:

- 101 - Polyethylene terephthalate or oriented polyamide film
- 102 - Urethane adhesive layer
- 103 - Aluminum foil
- 111 - Polypropylene, polyamide or polyethylene terephthalate hot melt coating.

Referring to Figure 8, bottom laminate 119, from the inside layer to the outside layer, is composed of:

- 111 - Polypropylene, polyamide or polyethylene terephthalate hot melt coating
- 103 - Aluminum foil
- 102 - Urethane adhesive layer
- 101 - Polyethylene terephthalate or oriented polyamide film.

As seen in Figure 8, aluminum tab(s) 107 lies between and is bonded (tab seal 110) to hot melt coatings 106 to laminate 120 and bottom laminate 119. The hot melt polymer 106 seals around tabs 107 are very tight seals which essentially prevent electrolyte leakage and moisture incursion.

A comparison of the sealing around the tabs 107 in prior art lithium ion battery 100 and invention lithium ion battery 121 is shown in Figures 9 and 10. Prior art lithium ion battery 100 in Figure 9 is the same as in Figures 1 to 4.

Figure 10 is a cross-sectional view of embodiments of invention lithium ion battery 121. Referring to Figure 10, top laminate 123, from the outside layer to the inside layer, is composed of:

- 101 - Polyethylene terephthalate or oriented polyamide film
- 102 - Urethane adhesive layer
- 103 - Aluminum foil
- 106 - Acrylic acid modified polyethylene, or polypropylene or maleic anhydride modified propylene sealant layer
- 111 - Polypropylene, polyamide or polyethylene terephthalate hot melt coating.

Referring to Figure 10, bottom laminate 122, from the inside layer to the outside layer, is composed of:

- 111 - Polypropylene, polyamide or polyethylene terephthalate hot melt coating
- 106 - Acrylic acid modified polyethylene, or polypropylene or maleic anhydride modified propylene sealant layer
- 103 - Aluminum foil

- 102 - Urethane adhesive layer
- 101 - Polyethylene terephthalate or oriented polyamide film.

The hot melt polymer tab seal areas of invention battery 121 are much better than the tab seal areas of prior art battery 100.

Figure 11 to 16 shows a fin-seal type pouch embodiment of invention lithium ion battery 124. Figure 11 is a perspective view of the lithium ion battery 124 with pouch body 125 with fin-seal portion 126. Two electrically conductive metal (preferably aluminum) tabs 107 extend beyond front perimeter region 127 of battery 124. See Figure 15, which shows the front end of battery 124. Figures 13 and 14 show the back end of battery 124. Body 125 and fin-seal portion 126 are composed of laminates used in the invention. Battery 124 is composed of one piece of laminate, with front tab seal 127, front fin-seal 128, back seal 129 and back fin-seal 130. Hot melt polymer 131 is coated on the inside surfaces of the laminate in the region of front tab seal 127 and laminate in the region of front tab seal 127 and front seal fin-seal 128. When front tab seal 127 and front fin-seal 128 are formed, hot melt polymer 131 completely seals around tabs 107. This is best shown in Figure 16. Hot melt polymer 131 is also coated on the inside of the laminate in the region of back seal 129 and back fin-seal 130. When back seal 129 and back fin-seal 130 are formed, hot melt polymer 131 completely seals the back region (hole or void) formed by the intersection of back seal 129 and back fin-seal 130. Figure 12 is a lateral cross-sectional

view of battery 124. Stacked bi-cells 108 are shown in central chamber 112. The electrolyte is contained in central chamber 112. The front and back seals are very tightly sealed by hot melt polymer 131 to electrolyte leakage and moisture (water and vapor) incursion.

Figure 17 to 19 show a three-sided seal (nonformable) pouch embodiment of the invention. Figure 17 is a top view of the lithium ion battery 132 with pouch body 133 with front tab seal region 134 and side seal regions 135, and with central chamber 136. Two electrically conductive metal (preferably aluminum, copper or nickel) tabs 107 extend beyond the front tab seal region 134. As shown in Figure 18, body 133 of battery 132 is formed by laminate 137 of the invention folded over on itself. Hot melt polymer 140 is coated on the inside surfaces of folded over laminate 137 in the region of front tab seal 134. When front tab seal 134 is formed, hot melt polymer 140 completely seals around tabs 107. This is best shown in Figure 19. Stacked bi-cells (not shown) and electrolyte are contained in central chamber 112. The front tab seal 134 is very tightly sealed by hot melt polymer 140 to electrolyte leakage and moisture incursion.

The state of the art seal strength, for instance, can be as follows:

State of the Art:

6 to 15 N/15mm

Invention:

>10 to 20 N/15mm

Therefore, typically, an increase in seal strength of 200 percent has been achieved. The seal strength as a function of the temperature of use is also of great importance. The seals must not fail under thermal and mechanical stress. Therefore, the choice of sealant material is very important. Besides its chemical resistance, the sealant must also provide high thermo-mechanical resistance. The choice of sealant in the invention concentrates on materials that have a melt point above the highest temperature to which the batteries are exposed. The highest temperature to which batteries are exposed to from a testing standpoint is 120°C, and, henceforth, the temperatures listed above. Long term testing is often carried out at 60°C for at least 30 days and 85°C for four (4) days. At such temperatures, the absence of leak and also a minimal electrolyte loss via migration through the seals are important.

The sealants of choice, therefore, have a melt point higher than the maximum temperature to which batteries are exposed, i.e., higher than 120°C.

One of the systems of choice involves a thin lacquer coating on the laminate foil:

Invention:

Polyamide or polyester film, 12 to 50 µm, preferably 12 to 30 µm

Adhesive or tie layer

Aluminum foil, 6 to 100 µm, preferably 20 to 60 µm, most preferred 20 to 50 µm

Polypropylene sealant, 3 to 50 μm , preferably 3 to 30 μm , most preferred 3 to 10 μm .

The invention material can be half as thick as the state of the art materials, mostly because it avoids the bulky sealant material in the laminate for the sealing of the tab area, and also eliminates the heat resistant films, such as, PET or oPA.

EXAMPLE 1

As a formable laminate structure of the invention:

Polyamide film, 25 μm
Urethane adhesive
Aluminum foil, 45 μm
Polypropylene coating, 6 μm

The invention could be formed into the same shapes as the state of the art material, i.e., to a depth of 4.5 mm with almost straight walls (4 degree angle, as with state of the art materials).

The seal resistance to electrolyte at elevated temperature was as follows, when formed, electrolyte filled and sealed packages were exposed to 60°C for 30 days:

State of the Art:

22 to 105 mg, depending upon structure

Invention:

1.8 to 3.0 mg

The above numbers express the amount of electrolyte that migrated through seals over a 30-day period. Therefore, the invention is at least seven (7) times tighter and more resistant to the electrolyte than the state of the art materials.

The tab area is sealed with the help of a hot melt, which is

also part of the invention. The hot melt compensates for the thickness difference around the tabs that can typically be from 20 to 100 microns thick, depending upon the battery. Hot melt of polyamide, polyester or polyolefin nature, preferably polypropylene-based, is applied on the laminate of the invention or on the tabs themselves to perfectly caulk the sides of such tabs and provides a perfectly tight seal. At the same time, the hot melt protects the tabs from coming in contact with the aluminum foil from the package, thus avoiding electric shorting of the battery.

The importance of the similar nature of the hot melt with the sealant from the laminate is to facilitate the heat seal process. The hot melt and the sealant from the laminate of the invention are sealed together with the tabs and the remainder of the perimeter regions are sealed at the same time, with the same temperature, pressure and dwell time conditions.

The propylene sealant from the reduction to practice of the invention has a melting point of 150°C, and the hot melt has a melting point of 156°C, which allows a perfect match between the two materials during the heat sealing process.

The tab area is very difficult to keep tight to electrolyte migration over time using the state of the art material. As shown above, the same parallel test was conducted with formed, filled-with-electrolyte, sealed packages, this time both with tabs in both the state of the art materials and in material from

this invention with the hot melt. The tab material chosen was aluminum, 50 micron thick. The sealed packages were exposed to 60°C for 20 days, and the electrolyte loss was quantified:

State of the art materials
with sealed tabs:

111 to 736 mg loss depending
upon structure

Invention with
sealed tabs:

12 to 21 mg

The above data shows the amount of electrolyte that was lost through the seals, including the area of and around the sealed tabs after the 20 day period. It is, therefore, apparent that the material of the invention, together with the invention hot melt concept for sealing the tabs is at least five (5) times higher in performance than the state of the art system. The invention can also provide further reduction of the amount of electrolyte loss.

In addition to these remarkable performance improvements in terms of battery protection, the laminate of the invention is typically 25 percent lighter than the state of the art materials. At the same time, the material of the invention is also typically 40 percent thinner than state of the art material for formable structures.

Furthermore, different sizes and thickness of tabs can easily be accommodated by varying the amount of hot melt that is applied in order to caulk the sides of such tabs. This can be done without having to modify the laminate of the invention. On

the contrary, when using the state of the art materials, the sealant layer needs to be varied in order to accommodate thicker or thinner tabs. Therefore, if the tabs are 80 microns thick, instead of 50 microns, the sealant material in the state of the art laminates will almost have to be doubled in thickness in order to provide a tight seal around the tabs. This will also impact the overall migration of electrolyte and moisture through the seal, because the thicker the seal, the larger the migration path for the electrolyte and for moisture. In addition, the cost of the structure goes up as well. Furthermore, the side seals that need to be folded are also thicker and take more space, while becoming more difficult to fold, because of the bulky nature of the state of the art laminate.

The invention overcomes all these drawbacks with proper dosage of hot melt in the tab seal area, without compromising any of the side seals. Migration can always be kept at a minimum and the folding of the side seals is not impacted at all.

The seal area, which then needs to be folded, is comprised of two layers of material of the invention or of state of the art material. Therefore, the thickness of the seals is also 40 percent thinner with the invention, which provides a tremendous decrease in the space (volume) lost to the folded seals. In addition, the material of the invention has a characteristically improved deadfold performance compared to the state of the art material. This makes the folding process tremendously easier,

which is another advantage of the invention.

If forming is not desired, a thinner laminate on the basis of the invention can be used:

Polyester or polyamide film, 9 to 12 μm
Urethane adhesive
Aluminum foil, 10 to 25 μm
Polypropylene coating, 3 to 6 μm

In order to ascertain that there is absolutely no pinholes in the aluminum foil of the preferred embodiment, a minimum thickness of foil of 20 to 25 microns is most preferred.

EXAMPLE 2

Laminates are used to prepare a non-formable lithium ion battery. The laminates are composed of:

Polyester film, PET 12 μm
Urethane adhesive
Aluminum foil, 25 μm
Polypropylene coating, 3 μm

The hot melt is also used to seal and caulk the metal tabs with the laminate of the invention to provide a perfectly tight seal.

If a fin-sealed type pouch is made, it is known in the art, that the two ends where the fin-seal joins the end seals is most critical from an integrity standpoint. The invention also applies a hot melt at the joint between the fin-seal and the end seals, in addition to the tab areas.

Claims:

1. A battery characterized in, that the battery comprises of
 - (a) a first laminate layer having a perimeter region and a central region,
 - 5 (b) a second laminate layer having a perimeter region and a central region,
the first and second laminate layers each comprising a metal foil, an outer polymer layer bonded to one side of the metal foil, and a hot melt polymer coating on the other side of the metal foil in at least perimeter region of the metal foil, the hot melt polymer coatings in the perimeter regions of the first and second laminate being
10 sealed together,
 - (c) a central chamber formed by the central regions of the first and second laminate layers, and
 - (d) an anode, a cathode and electrolyte arrange in an electrical current producing and conducting manner in the central chamber, and
 - 15 (e) two electrically conductive connector strips positioned between the two perimeter regions, one end of the connectors adapted for connection to an anode in the central chamber, one end of the other connector adapted from connection to a cathode in the central chamber, each other end of the two connectors extending beyond the perimeter regions of the laminates.
- 20 2. A battery packaging characterized in, that the battery packaging comprises of
 - (a) a first laminate layer having a perimeter region and a central region,
 - (b) a second laminate layer having a perimeter region and a central region,
the first and second laminate layers each comprising a metal foil, an outer polymer
25 layer bonded to one side of the metal foil, and a hot melt polymer coating on the other side of the metal foil in at least perimeter region of the metal foil, the hot melt polymer coatings in the perimeter regions of the first and second laminate being sealed together,
 - (c) a central chamber formed by the central regions of the first and second laminate
30 layers, and
 - (d) two electrically conductive connector strips positioned between the two perimeter regions, one end of the connectors adapted for connection to an anode in the central chamber, one end of the other connector adapted from connection to a cathode in the central chamber, each other end of the two connectors
35 extending beyond the perimeter regions of the laminates.

3. A battery characterized in, that the battery is a lithium battery comprising:
- (a) a first laminate layer having a perimeter region and a central region,
 - (b) a second laminate layer having a perimeter region and a central region,
- the first and second laminate layers each comprising a metal foil, an outer polymer layer bonded to one side of the metal foil, and an inner polymeric sealant layer on the other side of the metal foil, the inner polymeric sealant layers of the perimeter regions of the first and second laminates being sealed together,
- (c) a central chamber formed by the central regions of the first and second laminate layers, and
 - (d) an anode, a cathode which is a lithium compound or alloy, and electrolyte arranged in an electrical current producing and conducting manner in the central chamber,
 - (e) two electrically conductive connector strips positioned between the two perimeter regions, one end of the connectors connected to the anode, one end of the other connector connected to the cathode, each other end of the two connectors extending beyond the perimeter regions of the laminates,
- a hot melt polymer being located in a sealing manner between each of the connectors and the perimeter regions of the sealant layers in the area of an around each of the connectors.
4. The battery according to Claim 3 characterized in, that metal foil is aluminum foil, soft annealed aluminum alloy foil, copper foil, soft annealed copper alloy foil or nickel.
5. The battery according to Claim 3 characterized in, that the lithium battery is a lithium polymer battery, and the metal foil is an aluminum foil.
6. The battery according to Claim 3 characterized in, that the lithium battery is a lithium ion battery.
7. The battery according to Claim 6 characterized in, that metal foil is aluminum foil having a thickness of 5 to 100 μm .
8. The battery according to Claim 7 characterized in, that the aluminum foil is soft annealed aluminum foil.

9. The battery according to Claim 6 characterized in, that the inner polymeric sealant layer is a maleic anhydride grafted polypropylene, an epoxy-propylene material or system, propylene, an acrylic acid modified propylene, polyethylene, a polyamide, a polyester or a urethane.
- 5
10. The battery according to Claim 9 characterized in, that the inner polymeric sealant layer is a polyamide or polyethylene terephthalate.
- 10
11. The battery according to Claim 9 characterized in, that the inner polymeric sealant layer has a thickness of 5 to 100 μm .
12. The battery according to Claim 11 characterized in, that the inner polymeric sealant layer has a melting point of at least 120 $^{\circ}\text{C}$.
- 15
13. The battery according to Claim 6 characterized in, that the hot melt polymer is a maleic anhydride grafted polypropylene, an epoxy-propylene material or system, propylene, an acrylic acid modified propylene, a polyamide, a polyester or a urethane, which has been hot melt applied.
- 20
14. The battery according to Claim 13, characterized in, that the hot melt polymer is polypropylene, a polyamide or polyethylene terephthalate, which has been hot melt applied.
- 25
15. The battery according to Claim 13 characterized in, that the hot melt polymer has a melting point of at least 120 $^{\circ}\text{C}$ and which is similar to the melting point of the inner polymeric sealant layer.
16. The battery according to Claim 6 characterized in, that the outer polymeric layer is a polyester or a polyamide.
- 30
17. The battery according to Claim 16 characterized in, that the outer polymeric layer has a thickness of 12 to 50 μm .
- 35
18. The battery according to Claim 16 characterized in, that the outer polymeric layer is a biaxially oriented polyamide, a biaxially oriented polyester or biaxially oriented

polypropylene.

- 5
19. The battery according to Claim 6 characterized in, that the outer polymeric layer is bonded to the metal foil by means of an adhesive layer or a tie layer.
20. The battery according to Claim 19 characterized in, that the adhesive layer is a solvent based or solvent free urethane based adhesive or polyester based adhesive or epoxy-based one or two component adhesive.
- 10 21. The battery according to Claim 19 characterized in, that tie layer is a polyethylene, polypropylene or acrylic acid modified polyolefin, such as, polyethylene and polypropylene.
- 15 22. The battery according to Claim 6 characterized in, that the lithium battery has a pouch shape, or has a rectangular straight wall shaped cavity, or is of the three-sided fin-seal type pouch.
- 20 23. The battery according to Claim 6 characterized in, that the hot melt polymer is a coating over the entire surface of each of the inner polymeric sealant layers.
24. A battery packaging characterized in, that the battery packaging is for a lithium battery comprising:
- 25 (a) a first laminate layer having a perimeter region and a central region,
- (b) a second laminate layer having a perimeter region and a central region,
- the first and second laminate layers each comprising an aluminum foil, an outer polymer layer bonded to one side of the aluminum foil, and an inner polymeric sealant layer on the other side of the aluminum foil, the inner polymeric sealant layers of the perimeter regions of the first and second laminates being sealed together,
- 30 (c) a central chamber formed by the central regions of the first and second laminate layers, and
- (d) two electrically conductive connector strips positioned between the two perimeter regions, one end of the connectors adapted for connection to an anode in the central chamber, one end of the other connector adapted for connection to

a cathode in the central chamber, each other end of the two connectors extending beyond the perimeter regions,
a hot melt polymer being located in a sealing manner between each of the connectors and the perimeter regions of the sealant layers in the area of an around each of the
5 connectors.

25. A battery characterized in, that the battery is a lithium ion battery comprising:
- (a) a first laminate layer having a perimeter region and a central region,
 - (b) a second laminate layer having a perimeter region and a central region,
 - 10 the first and second laminate layers each comprising an aluminum foil, an outer polymer layer bonded to one side of the aluminum foil, and a hot melt polymer coating on the other side of the aluminum foil at least perimeter region of the aluminum foil, the hot melt polymer coating in the perimeter regions of the first and second laminates being sealed together,
 - 15 (c) a central chamber formed by the central regions of the first and second laminate layers,
 - (d) an anode, a cathode which is a lithium compound or alloy, and electrolyte arranged in an electrical current producing and conducting manner in the central chamber, and
 - 20 (e) two electrically conductive connector strips positioned between the two perimeter regions, one end of the connectors connected to the anode, one end of the other connector connected to the cathode, each other end of the two connectors extending beyond the perimeter regions of the laminates.

25 26. The battery according to Claim 25 characterized in, that the lithium battery is a lithium polymer battery.

27. The battery according to Claim 25 characterized in, that the lithium battery is a
30 lithium ion battery.

28. The battery according to Claim 27 characterized in, that the metal foil is aluminum foil having a thickness of 5 to 100 μm .

29. The battery according to Claim 28 characterize in, that the aluminum foil is soft
35 annealed aluminum foil.

- 5 30. The battery according to Claim 27 characterized in, that the inner polymeric sealant layer is a maleic anhydride grafted polypropylene, an epoxy-propylene material or system, propylene, an acrylic acid modified propylene, polyethylene, a polyimide, a polyester or a urethane.
31. The battery according to Claim 30 characterized in, that the inner polymeric sealant layer has a thickness of 5 to 100 μm and has a melting point of at least 120 °C.
- 10 32. The battery according to Claim 27 characterized in, that the hot melt polymer is a maleic anhydride grafted polypropylene, an epoxy-propylene material or system, propylene, an acrylic acid modified propylene, polyethylene, a polyamide, a polyester or a urethane, which has been hot melt applied.
- 15 33. The battery according to Claim 32 characterized in, that the hot melt polymer has a melting point of at least 120 °C and which is similar to the melting point of the inner polymeric sealant layer.
- 20 34. The battery according to Claim 27 characterized in, that the outer polymeric layer is a polyester or a polyamide.
35. The battery according to Claim 34 characterized in, that the outer polymeric layer has a thickness of 12 to 50 μm .
- 25 36. The battery according to Claim 34 characterized in, that the outer polymeric layer is a biaxially oriented polyamide, a biaxially oriented polyester or biaxially oriented polypropylene.
- 30 37. The battery according to Claim 27 characterized in, that the outer polymeric layer is bonded to the metal foil by means of an adhesive layer or a tie layer.
38. The battery according to Claim 37 characterized in, that the adhesive layer is a solvent based or solvent free urethane based adhesive or polyester based adhesive or epoxy-based one or two component adhesive.
- 35 39. The battery according to Claim 37 characterized in, that the tie layer is polyethylene,

polypropylene or acrylic acid modified polyolefin, such as, polyethylene and polypropylene.

- 5 40. The battery according to Claim 27 characterized in, that the lithium battery has a pouch shape, or has a rectangular straight wall shaped cavity, or of the three-sided fin-seal type pouch.
- 10 41. A battery packaging characterized in, that the battery packaging is for a lithium battery comprising:
- 15 (a) a first laminate layer having a perimeter region and a central region,
(b) a second laminate layer having a perimeter region and a central region,
the first and second laminate layers each comprising an aluminum foil, an outer polymer layer bonded to one side of the aluminum foil, and a hot melt polymer coating on the other side of the aluminum foil in at least perimeter region of the
20 aluminum foil, the hot melt polymer coatings in the perimeter regions of the first and second laminate being sealed together,
(c) a central chamber formed by the central regions of the first and second laminate layers, and
(d) two electrically conductive connector strips positioned between the two
perimeter regions, one end of the connectors adapted for connection to an anode in the central chamber, one end of the other connector adapted from connection to a cathode in the central chamber, each other end of the two connectors extending beyond the perimeter regions of the laminates.

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FIG. 1
PRIOR ART

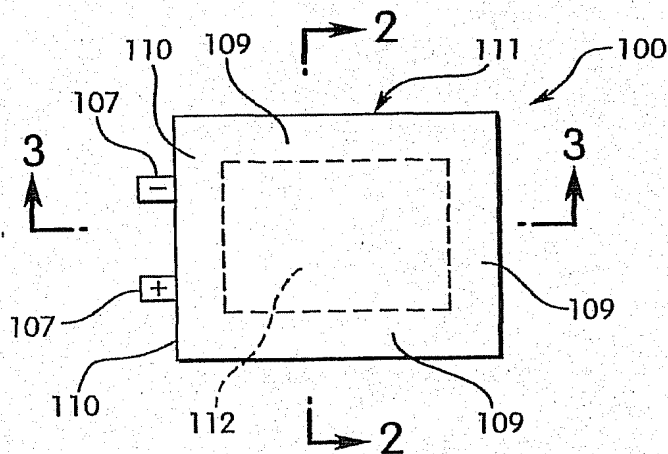


FIG. 2
PRIOR ART

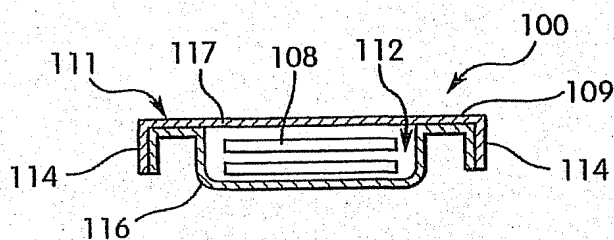


FIG. 3
PRIOR ART

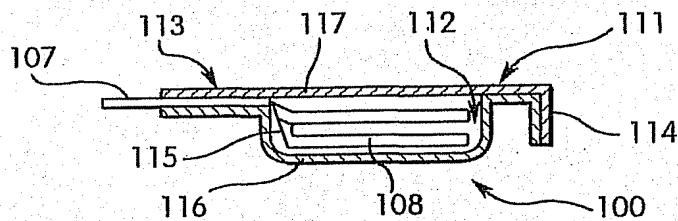
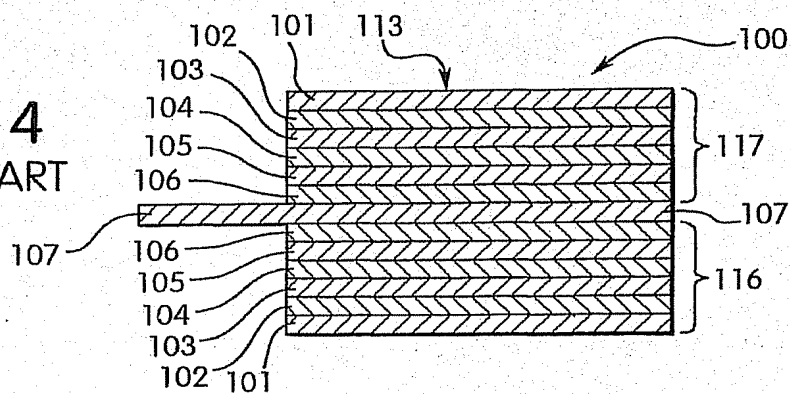


FIG. 4
PRIOR ART



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FIG. 5

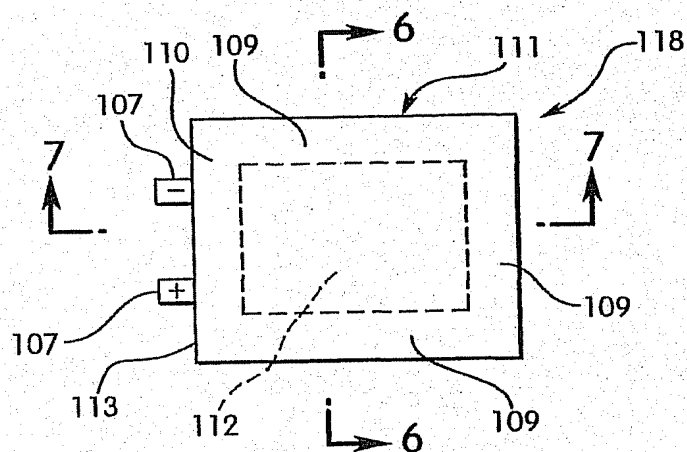


FIG. 6

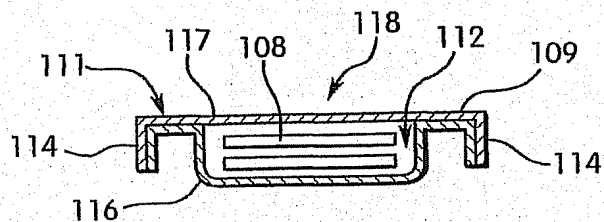


FIG. 7

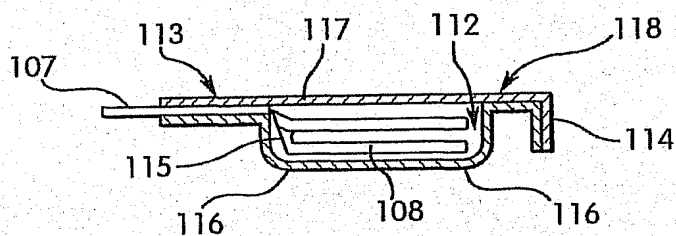
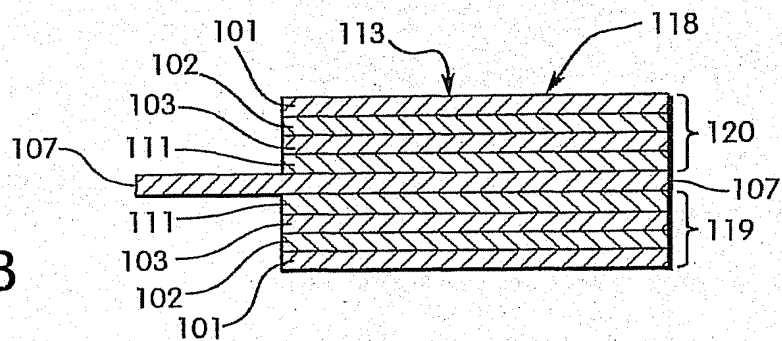


FIG. 8



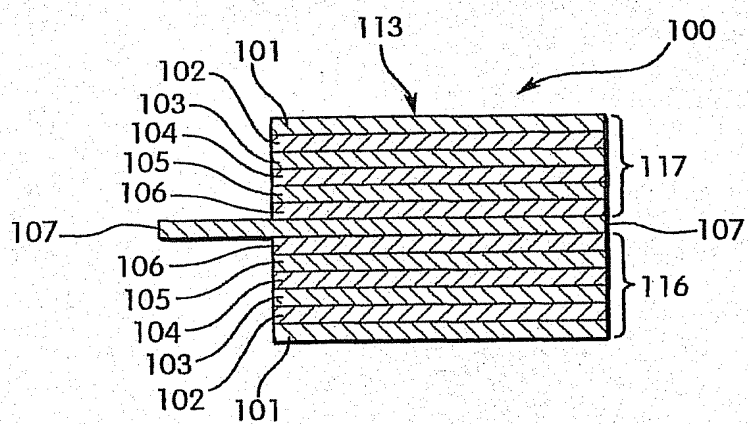


FIG. 9
PRIOR ART

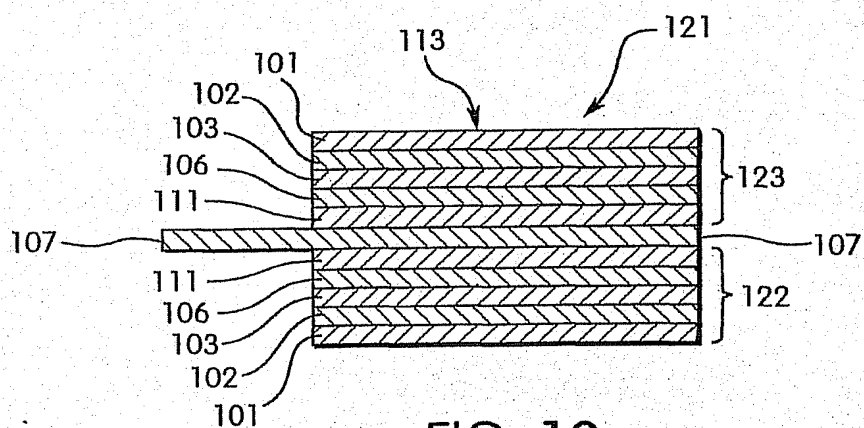


FIG. 10

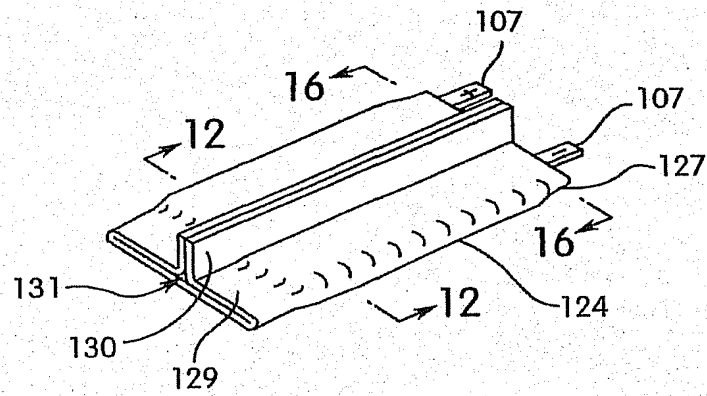


FIG. 11

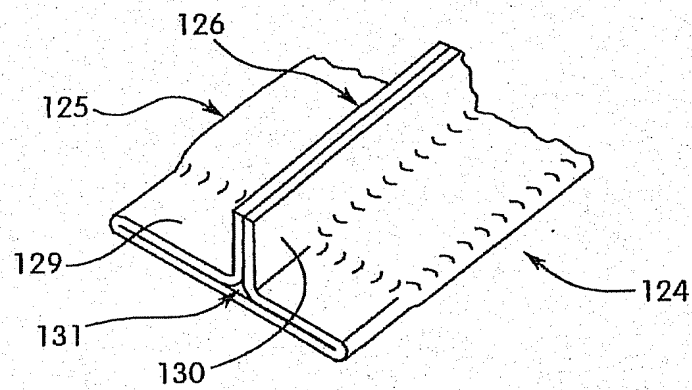


FIG. 13

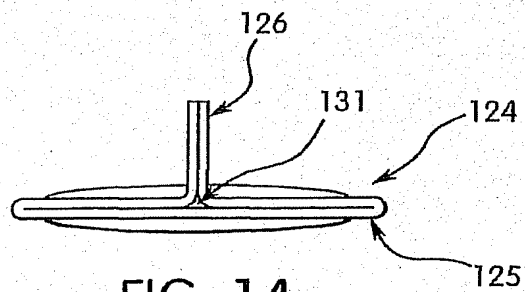


FIG. 14

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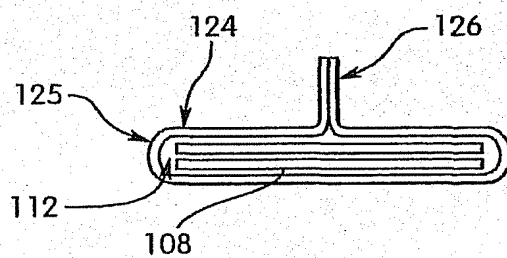


FIG. 12

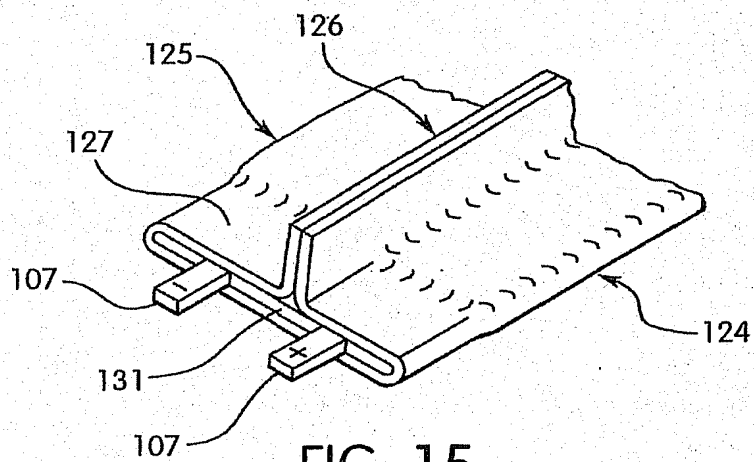


FIG. 15

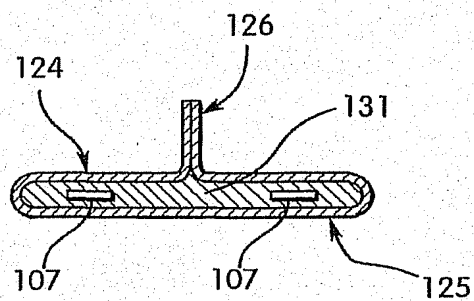


FIG. 16

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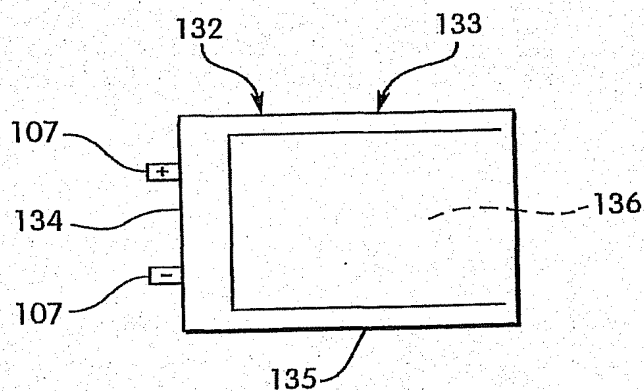


FIG. 17

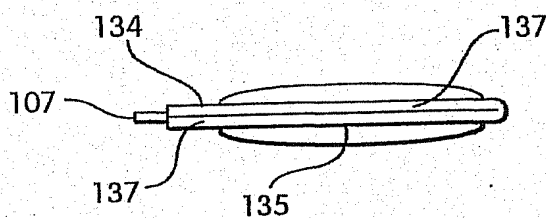


FIG. 18

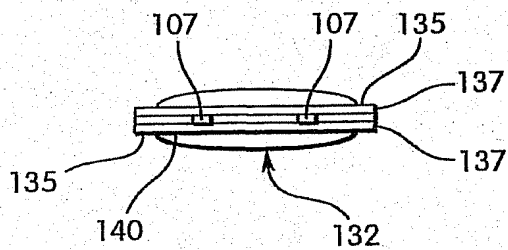


FIG. 19

INTERNATIONAL SEARCH REPORT

International Application No

PCT/CH 01/00042

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01M2/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 997 732 A (AUSTIN ROBERT A ET AL) 5 March 1991 (1991-03-05) claims 1-10	1,2
X	EP 0 390 557 A (MHB JOINT VENTURE) 3 October 1990 (1990-10-03) page 3, column 3, line 35 - line 55; claims 1-25; figure 1 column 11, line 25 - line 40	1,2
A	US 3 997 365 A (FELDHAK RALPH H) 14 December 1976 (1976-12-14) claims 1-12	1-41
A	US 4 678 725 A (KIKUCHI YOICHI ET AL) 7 July 1987 (1987-07-07) claims 1-8	1-41

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

9 July 2001

Date of mailing of the international search report

16/07/2001

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Battistig, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CH 01/00042

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